Hydrology Training Series

Number Computations

Module 104 - Runoff Curve

Study Guide

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Module Description

Objectives

Upon completion of this module, the participant will be able to:

1. List and describe the elements needed to calculate a runoff curve number.
2. Calculate a runoff curve number from given field data.
3. Calculate a runoff curve number for complex areas.

The participant should be able to perform at ASK Level 3 (Perform with Supervision) after completing this module

Prerequisites

Module 103 - Runoff Concepts

Equipment Needed

A dot grid training aid is needed to complete this module.

Who May Take the Module

This module is intended for all NRCS personnel who calculate runoff curve numbers for a drainage area.

Content

Elements needed to calculate a runoff curve number and actual calculations of runoff curve numbers using given field data are presented in this module.

Introduction

The NRCS method of estimating volume runoff is based on procedures developed over the last three decades. Because most NRCS work is with ungauged watersheds, this method is usable with easily attainable watershed parameters and rainfall data. In this module, you will learn to compute a runoff curve number, which can then be used in runoff calculations.

A more detailed discussion on the estimation of a hydrologic soil cover complex from watershed parameters, hydrologic soil groupings, land use and treatment classes is found in Chapters 7, 8, and 9, respectively of Section 4, National Engineering Handbook.

Elements Needed to Compute Runoff Curve Numbers

NRCS has developed a method of combining the effects of soils, watershed characteristics, and land use into a single parameter. This parameter is the runoff curve number (CN) and represents the hydrologic soil cover complex of the watershed. A single runoff curve number can be developed for a watershed with a single land use and one soil type, and for a watershed with a combination of soils and land uses.

Runoff curve numbers are limited to:

1. Single events
2. Maximum 24-hour duration rain events.
3. Areas with unfrozen ground conditions.
4. Representation of average watershed conditions when flooding or conditions when annual flood event occurs.
5. Direct runoff volume.

The elements needed to compute a runoff curve number for a watershed are soil type and cover description, which is combination of cover type, land treatment, and hydrologic condition. Soil type and cover description are easily obtained. The information needed and the sources of this information will be discussed in detail in the first section of this module. The second section will discuss how to compute an average runoff curve number for a watershed, a drainage area, or a field.

Soil Type

The Soil Conservation Service has a wealth of soils information, including soils, maps throughout the United States. Part of this information relates to soil names and their relative intake or infiltration rate. Each soil symbol on the map has a related soil name. Associated with that name is the infiltration rate, soil texture, depth, hydrologic soil group, etc. Basic soils information is listed on the soil interpretation sheets.

Soil properties

Soil properties influence the peak rate of runoff from rainfall and must be considered. The single most important soil property is the minimum rate of infiltration obtained for a bare soil after prolonged wetting. Soils have been grouped according to the infiltration rate (surface conditions) and transmission rate (profile conditions). The four hydrologic soil groups as defined by NRCS are described in Module 103 - Runoff Concepts.
The final infiltration capacity has been determined for a wide range of bench mark soils or key soils using infiltrometers. Infiltrometers are devices used to measure the intake rate of soil. The remainder of the soils has been classified by soil scientists using correlation techniques.

Chapter 2, EFM, and Appendix A, TR-55 (Study Guide Appendix A) list more than 9000 soils that have been mapped and assigned soil series names and hydrologic soil groups. Some states have developed individual state listings and have issued these as a technical note.

Some soils can change hydrologic groupings depending on the water table. This is covered by footnote in Appendix A For example; Adrian AID is hydrologic soil group "A" when drained and "D" when undrained.

In some locations, urban activities may change the hydrologic soil group because of compaction, loss of the A horizon, and reshaping or grading of the landscape. There is a discussion on page A-1 ofTR-55 explaining how a disturbed soil profile in an urban area may be evaluated.

The local soil scientist can provide assistance in selecting the correct hydrologic soil groups if the soil is not listed or if local conditions might alter information in Appendix A

Precise measurement of soil-group areas by plan metering soil areas or weighing map cuttings is seldom necessary for hydrologic purposes. Normally, the percentage of the watershed occupied by a soil type can be determined using the dot counter techniques.

Example

From a sample soils map for an indicated watershed, determine the percentage of the watershed in each hydrologic soil group.

1. Outline the watershed on a soils map.
2. Classify the soils into group A, B, C, or D on the soils map or transfer this information to a topographic map of the watershed.
3. . Place a grid or dot counter over the watershed soils map, count the number of grid intersections falling on each soil group, and tabulate. A planimeter can be used to measure the area of each soil group and land use.
4. Determine the percentage for each hydrologic soil group within the watershed. Simplified versions for determining the extent of soil groups are often used in practice. Often the soil types may fall predominantly into one or two hydrologic soil groups. *As* a general rule, two groups can be combined if one is less than three percent of the watershed. A serious under-estimation of runoff can result if a watershed with 90% of its soils in the "A" group and 10% in "D" is classified as all "A," since most of its storm runoff could come from the "D" soils.
5. . If there is some question about how to prepare a hydrologic soil grouping map or estimate the percent of each soil group within the watershed, talk to a local soil scientist.

Cover Description

Vegetation affects peak rates of runoff in several ways:

1. The foliage and its litter maintain the soil's infiltration potential by preventing the sealing of the soil surface from the impact of the raindrops.
2. Some of the raindrops are retained on the surface of the foliage, increasing their chance of being evaporated back to the atmosphere.
3. Some of the intercepted moisture takes so long to drain from the plant to the soil that it is withheld from the initial period of runoff.

Conservation practices, in general, reduce sheet erosion and thereby maintain an open structure of the soil surface. This reduces the volume of runoff but the effect diminishes rapidly with increase in storm magnitude.

Contouring and terracing reduce sheet erosion and increase the amount of rainfall withheld from runoff by the small reservoirs they form. Leaving residue on the soil surface and no-till or minimum tillage practices also help reduce the volume of runoff.

Rural cover types
The typical rural cover types, as shown in Chapter 2, EFM and Table 9.1, NEH-4, include:

1. **Fallow** - Agricultural land kept as bare as possible to conserve moisture for use the following year.
2. **Row Crop** - Any field crop planted in rows far enough apart so as to expose most of the soil surface to the impact of rainfall.
3. **Small Grain** - Wheat, oats, barley, flax, etc., planted in rows close enough that the soil surface is not exposed except during or shortly after planting.
4. **Close-seeded legumes or rotation meadow** - Alfalfa, sweet clover, timothy, etc., or combinations, which are either planted in close rows or broadcast.
5. **Grassland** - Is evaluated using the three hydrologic conditions of native pasture or range, which are based on cover effect, not forage production.
    a. Poor-heavily grazed. Either has no mulch or has plant cover on less than 1/2 of the area.
    b. Fair-not heavily grazed. Has plant cover on 1/2 to 3/4 of the area.
    c. Good-lightly grazed. Has plant cover on more than 3/4 of the area.
6. **Meadow** -A field on which grass is grown continuously, protected from grazing, and generally mowed for hay.
7. **Woods** - Small isolated groves of trees being raised for farm or ranch use.
    a. Poor-heavily grazed or regularly burned litter, small trees, and brush are destroyed
    b. Fair-grazed, but not burned. There may be some litter, but these woods are not protected.
    c. Good-protected from grazing. Litter and shrubs cover the soil.
8. **Forests** - Areas covered by national or commercial forests. The U.S. Forest Service has a procedure for determining hydrologic conditions on forest lands. Many times they will develop their information in Forest Hydrologic Condition Classes. Chapter 9, NEH-4 contains further information on the Forest Service procedure.
9. **Water Surfaces** - Lakes, ponds, marshes, etc.
10. **Impervious Surfaces** - Roads, roofs, parking lots, etc. outside typical urban cover types.

Urban cover types

The typical urban cover types, as shown in Table 2-2a, TR-55, (Appendix A) include:

1. **Residential houses** - on various lot sizes. This includes the impervious areas of the roof, streets, driveways, etc. within the subdivision with the typical percent impervious shown.
2. **Commercial and business** - small business shops, etc. along a street with the typical percent impervious shown.
3. **Industrial-** manufacturing areas with the typical percent impervious shown.
4. **Streets and roads** - paved areas, both including and excluding right of way. Unpaved areas include right of way.
5. **Open areas** - urban areas where vegetation has been established. Could include lawns, parks, golf courses, cemeteries, etc.
6. **Newly graded areas** - urban areas where the ground has been shaped or disturbed and where no vegetation has been established.
7. **Connected Impervious areas** - urban areas where the impervious area is directly connected to the storm water drainage system.
8. **Unconnected Impervious area** - urban areas where the impervious area is not directly connected to the storm water drainage system. For example, outflow from the downspout is allowed to spread over the lawn before entering the storm water drainage system

Land treatment

Agricultural land management includes mechanical practices, such as contouring, terracing, and rotation. These types of management practices also reflect or influence the hydrologic condition of the particular land use.

1. **Rotations** - are planned sequences of crops; hydrologically, rotations range from "poor" to "good" in proportion to the amount of dense vegetation in the rotation.
    a. Poor rotations are generally one cropland use, such as continuous corn, wheat, or combinations of row crops, small grain, and fallow.
    b. Good rotations generally contain alfalfa or other close-seeded legumes or grasses to improve tilth and increase infiltration.

2. **Straight Row-**fields are those farmed in straight rows either up and down hill or across the slope. Where land slopes are less than about 2 percent, farming across the slope in straight rows is equivalent to contouring.

3. **Contouring** - contoured fields have been farmed on the contour and their hydrologic effect is to increase the surface storage by providing furrows.

4. **Terracing** - refers to graded or open-end terraces with outlets and their hydrologic effect is to increase storage and opportunity for infiltration.

Land use and treatment classes can be readily obtained by observation, recent photos, or by consultation with work unit personnel.

Locations of the classes within the same hydrologic watershed unit used for the soil groups are usually ignored. The classes are tabulated using percentages or acreages. The accuracy of the areal extent of the data should be compatible with that of the soil group data.

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Hydrologic Soil Cover Complex

The combination of hydrologic soil group and cover type information results in a hydrologic soil cover complex. Each hydrologic soil cover complex has been assigned a runoff curve number. The CN indicates the runoff potential of a hydrologic soil cover complex. The higher the CN, the higher the runoff potential.

Runoff curve numbers represent the median condition of the hydrologic soil cover complex when the largest annual flood occurs. This is the assumed hydrologic soil cover complex condition when the design flood of a conservation measure occurs.

Runoff curve numbers are to be used with single flood event models and not with continuous hydrologic models.

Runoff curve numbers should not be used to estimate the impact of frozen ground or frozen ground with snow cover on the design peak flow estimate.

Individual states may have developed supplemental curve numbers for hydrologic soil-covers complexes not identified in either Chapter 2, EFM or Chapter 2, TR-55. These documents should be used where applicable.

Runoff curve number computations

The runoff curve numbers for a wide range of hydrologic soil cover complexes are shown in Chapter 2, EFM and Chapter 2, TR-55. Each document lists the runoff curve numbers for specific cover descriptions.

Rural Cover Description

The runoff curve number for a wide range of rural hydrologic soil cover complexes are shown in Chapter 2, EFM and Chapter 2, TR-55.

Urban Cover Description

The runoff curve numbers for a wide range of urban hydrologic soil cover complexes are shown in Chapter 2, TR-55. While urban CN's are also given in Chapter 2, EFM, some restrictions apply to their use. Therefore, use TR-55 when working with urban areas. The runoff curve numbers for the urban hydrologic soil cover complex *are* for the specific percent impervious shown in Chapter 2, TR-55. The values shown represent the average percent impervious for that cover description.

If your percent impervious for a listed cover description is different, then develop a new CN for that hydrologic soil cover complex as follows:

(% area impervious) (98) + (1- % impervious) (CN open space in good condition for that soil)

For example, one-acre lots on a C hydrologic soil group have total impervious area percentage of 15. The estimated CN would be:

(0.15) (98) + (1- 0.15) (74) = 77.6 = 78

The impervious runoff curve number from Table 2-2a is 98 and open space in good condition on a C hydrologic soil group from Table 2-2a is 74.

CN Computations for Complex Areas

The runoff curve number for a complex hydrologic soil-cover complex is developed by weighing areas of *CNs* within the total drainage area as:

(CN) x (acres) =
(CN) x (acres) =
(CN) x (acres) =

or

(CNX%=
(CNX %) =
(CNX %) =

Total Product

Weighted CN = Total Area = to the nearest whole value

For example, using acres and Chapter 2, EFM:

Hydrologic soil cover complex	Acres	CN	Product
Row Crop-Soil B (contoured, good)	220	75	16,500
Row Crop-Soil D (straight row, good)	150	89	13,350
Pasture-Soil D (good)	30	80	2,400
	400		32,250

Weighted CN= 32,250 divided by 400 =80.6 = 81 to nearest whole value

For example, using % and Chapter 2, TR-55:

Hydrologic soil Cover complex	Acres	%	CN	Product
House-Soil C (1/2 acre lots)	220	0.550	80	44
Commercial—Soil D	150	0.375	95	37
Open Areas- Soil D (Good)	30	0.075	80	6
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	.400	1.000		87

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Summary

In summary, we have learned that a runoff curve number for a watershed with a mixture of cover descriptions and soil types can be easily determined. Each soil cover complex has a unique runoff curve number.

The hydrologic soil group information is in either Appendix A, TR-55 or Chap. 2, EFM. Urban cover description CN's are shown in Table 2-2a, TR-55 and rural CN's are shown in Chapter 2, EFM.

The CN's are to be used with single event design storms or events and represent the median condition when the largest yearly event occurs. They do not account for the impact of frozen ground on runoff rates and should not be used in continuous models.

You have proven that you can calculate the runoff curve number for a complex watershed by two methods. You have also seen that the two methods produce identical results. The methods are simple and easy to use.

Retain this Study Guide as a reference until you are satisfied that you have successfully mastered all the methods covered. It will provide an easy review at any time if you should encounter a problem.

If you have had problems understanding the module or if you would like to take additional, related modules, contact your supervisor.

When you are satisfied that you have completed this module, remove the Certification of Completion sheet (last page of the Study Guide), fill it out, and give it to your supervisor to submit, through channels, to your State or NTC Training Officer.

Activity 1

From the sample soils map and legend sheet on the following pages, determine the percentage of the indicated watershed in each hydrologic soil group. Refer to Appendix A of your Study Guide for applicable charts and tables. For this Activity, do not assume the hydrologic soil group has changed because of the urban land complex.

SOIL LEGEND

Symbol	name	symbol	name
1	Aledo gravelly clay loam. 1 to 8 percent slopes	45	Mabank fine sandy loam, 0 to l percent .slopes
2	Aledo-Bolar complex. 5 to 20 percent slopes	46	Maloterre Aledo and Bracken soils 3 to 20 percent slopes
3	Aledo-Bolar-Urban land complex, 3 to 20 percent slopes	47	Medlin clay, 5 to 15 percent Slopes
4	Aledo-Urban land complex. 1 to 8 percent slopes	48	Mingo clay loam, l to3 percent slopes
5	Altoga Silty clay loam. 5 to 12 percent slopes	49	Mongo-Urban land complex. l '03 percent slopes
6	Aquilla loamy fine sand. 1 to 5 percent slopes	50	Navo clay loam. l '0 3 percent slope.
7	Arents, frequently flooded Are n. loam "	51	Neva-Urban land complex. 1 '03 percent Slope.
8		52	Nimrod fine sand. l '0 5 percent slope.
9	Bastsil fine sandy loam		
10	Bastsil¡ Urban land complex. 0 to 5 percent slopes	53	Ovan clay. occasionally flooded
11	fine sandy loam. 1 to 5 percent slopes	54	Ovon clay. frequently flooded
12	Birome-Aubrey-Rayex complex. 5 to 1 5 percent lopes	55	Ovan-Urban land complex, occasionally flooded
13	Birome-Aubrey-Urban land complex, 5 to 15 percent slopes	56	Pits, quarries.
14	clay loam, 1 to 3 percent slopes	57	Ponder clay loam. l to 3 percent slope.
15	Clay loam. 3 to 5 percent slopes	58	Ponde,-Urban land complex, 0 to 3 percent slope
16	Bolar-Urban land complex, 1 to 5 percent slopes	59	Pulex fine sandy loams. frequently flooded
17	Brackett clay loam, 3 to 8 percent slopes	60	Pule Urban land complex. occasionally flooded
18	Branyon clay, 0 to 1 percent slopes	61	Purves clay. 0 to3 percent slopes
19	Burleson clay. 0 to 1 percent slopes	62	Purve Urban land complex, 0 to 3 percent slopes
20	Chan silty clay. 1 to 3 percent slopes	63	Rader fine sandy loam
21	Cross tell fine sandy loam. 1 to 3 percent slopes	64	Rader Urban land complex
22	Cross tell fine sandy loam. 3 to 6 percent slopes	65	Sanger clay. 1 to3 percent Slope.
23	Crosstell Urban land complex. 1 to 6 percent slopes	66	Sanger clay 3 to5 percent slope.
24	Ferris clay. 5 to 12 percent Slopes. eroded	67	Sanger-U.ban land complex, l to5 percent slopes
25	Ferrls Heujen complex. 2 to 5 percent slopes	68	San Slba clay, 0 to 2 percent. slopes
26	Frio silty clay. occasionally flooded	69	Selden loam fine sand. l to 3 percent slopes
27	Frio silty clay. frequently flooded	70	S,lawa lone sandy loam, 3 to8 percent slope
28	Frio-Urban land complex, occasionally flooded	71	Silstid loam lone sand, l to 5 percent Slope.
29	Gasll fine sandy loam. 1 to 3 percent slopes	72	SilStid-Urban land complex, l .to 5 percent. slopes
30	Gasll fine sandy loam. 3 to 8 percent slopes	73	Slidell clay, 0 to 1 percent slopes
31	Gasll sandy clay loam, graded. 1 to 5 percent slopes	74	Slodetl clay, 1 to 3 percent slope
32	Gasll-Urban land complex. 1 to 8 percent Slopes	75	Speck Clay loam, 0 to 3 percent slopes
33	Heiden clay. 1 to 3 percent slopes	76	percent fine sandy loom. 8 to 15 percent slope.
34	Houston Black clay. 1 to 3 percent slopes	77	Sunev clay loam, 1 to3 percent slope.
35	Houston Slack-Urban land complex(. 1 to 4 percent Slopes	78	Sunev clay loam. 3 to 8 percent slopes
36	Justin loam, 1 to 3 percent slopes	79	Sunev-Urban land complex. 2 to 8 percent slopes
37	Kensal fine sandy loam, 1 to 5 percent slopes	80	Trinity clay. frequently flooded
38	Leson clay. 1 to 3 percent Slopes	81	Urban land
39	Lindale clay loam. 1 to 3 percent slopes	82	Weatherford fine sandy loam. 3 to 8 percent slopes
40	Lindale--Urban land complex. 1 to 3 percent slopes	83	Whitesboro loam. frequently flooded
41	Lon Silty clay. 1 to 3 percent slopes	84	Wilson Clay loam. 0 to 2 percent slopes
42	LOUis Urban land complex(. 1 to 5 percent slopes	85	Wilson4Urban land complex. 0 to 2 percent slopes
43	Luckenbach clay loam. 1 to 3 percent slopes	86	Windthorst fine sandy loam. 1 to 3 percent slope
44	Luckenbach Urban land complex(. 1 to 3 percent slopes	87	Windthorst fine sandy loam, 3 to 8 percent slopes
		88	Windthorst fine sandy loam. 2 10 8 percent Slopes eroded

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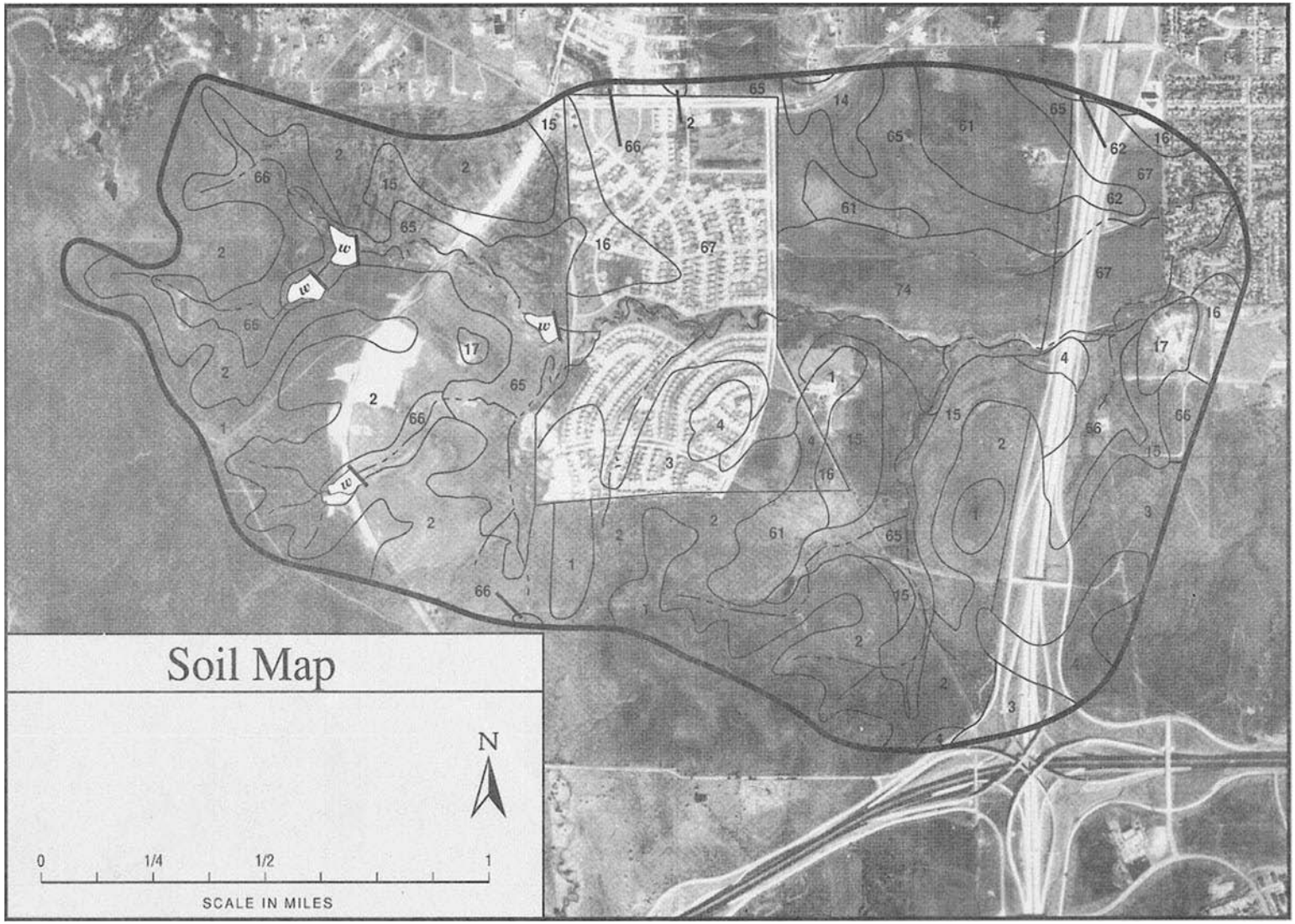
Soil Map
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SCALE IN MILES

Map Symbol	Soil Name	Hydrologic Soil Group	Acres/ Intersections	%
1	Aledo gr. clay loam, 1 - 8% slopes	C		
2	Aledo-Bolar complex, 5 - 20% slopes	C		
3	Aledo-Bolar-Urban land complex,3 - 20% slopes	C		
4	Aledo-Urban land complex,1 - 8% slopes	C		
14	Bolar clay loam, 1 - 3% slopes	C		
15	Bolar clay loam, 3 - 5% slopes	C		
16	Bolar-Urban land complex,1 - 5% slopes	C		
17	Bracket clay loam, 3 - 8% slopes	C		
61	Purves clay, 0 - 3% slopes	D		
62	Purves-Urban land complex,0 - 3% slopes	D		
65	Sanger clay, 1 - 3% slopes	D		
66	Sanger clay, 3 - 5% slopes	D		
67	Sanger-Urban land complex,1 - 5% slopes	D		
74	Slidell clay, 1 - 3% slopes	D		

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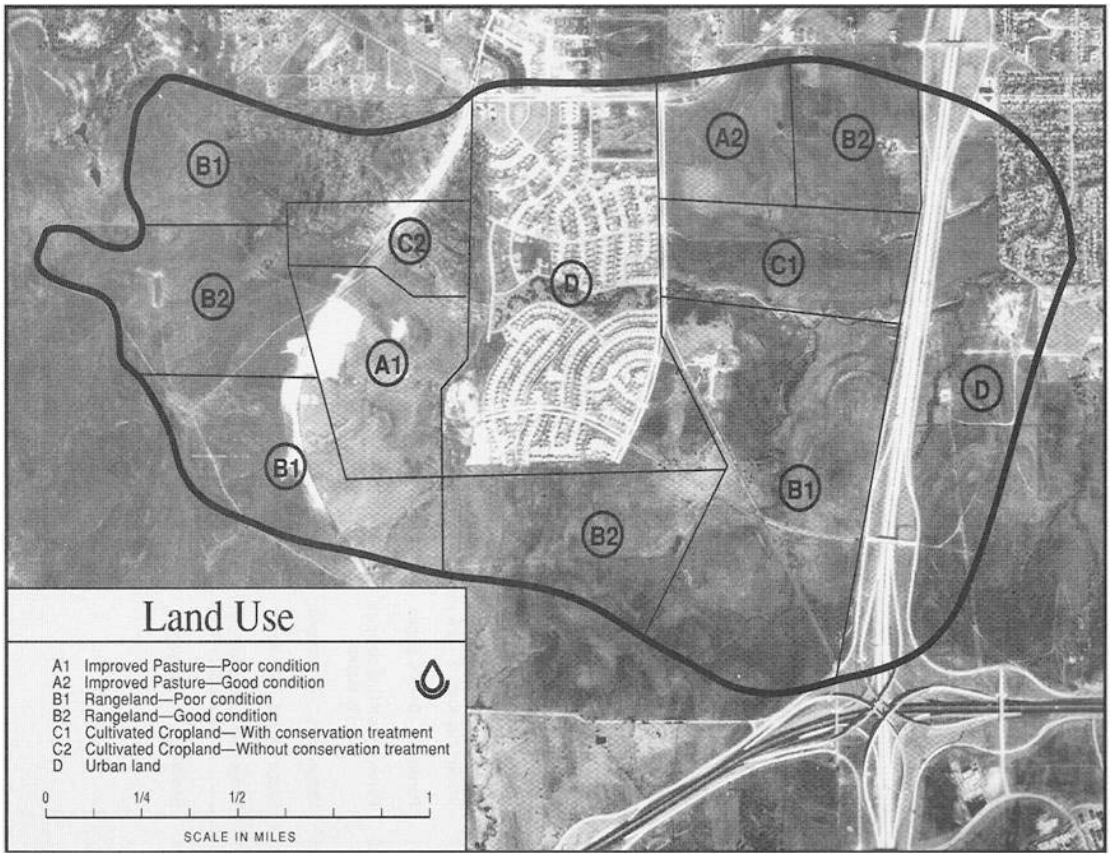
Activity 2

From the sample aerial photograph determine the percentage of the indicated watershed in each cover description. Refer to Appendix A of your Study Guide for applicable charts and tables.



Land Use	Acres	%
Improved Pasture - poor condition	112	
Improved Pasture - good condition	73	
Rangeland - poor condition	541	
Rangeland - good condition	334	
Cultivated cropland - with cons. treatment	96	
Cultivated cropland - *wlo* cons.treatment	53	
Urban land	605	
	=1,814	=100.0%

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Activity 3

Determine the runoff curve numbers for the hydrologic soil cover complexes listed below. Refer to Appendix A (2-2b) of your Study Guide for applicable charts and tables.

Hydrologic Soil Group	Cover Description	CN
B	Row crops - straight row & crop residue, in good condition	
B	Small grain - contoured, in poor condition	
B	Meadow - in good condition	
C	Woods - in fair condition	

Determine the runoff curve numbers for the hydrologic soil cover complexes listed below. Refer to Appendix A of your Study Guide for applicable charts and tables.

Activity 4

Determine the runoff curve number for the hydrologic soil cover complexes listed below. Refer to Appendix A (2-2a) in your Study Guide for applicable charts and tables

Hydrologic Soil Group	Cover Description	CN
A	Residential - 1 ac	
B	Commercial	
C	New graded area	
B	Residential-1ac. 18% impervious	

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Activity 5

Determine the weighted average runoff curve number for the watershed described below. Refer to Appendix A of your Study Guide for applicable charts and tables.

Soil Name	Cover Description	Acres	% Area	Hydrologic Soils Group	CN	Product
Dover	Row Crops-SR & CR in good condition	500	50	B		
Crofton	Small grain-contoured, in poor condition	300		B		
Greenville	Meadow-in good condition	150		B		
Odessa	Woods-in fair condition	50		D		
		=====	=====			====
		1,000	1.00			72.3
						Use 72

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Activity 6

Determine the weighted average runoff curve number for the watershed described below. Refer to Appendix A of your Study Guide and the hydrologic soil groups given in Activity 5 for applicable charts and tables

Soil Name	Cover Description	Acres
Dover	Row Crops-straight row and crop residue, in good condition	300
Newberg	Meadow-in good condition	200
Crofton	1 ac Residential	200
Odessa	Industrial	100
Dover	1/2 ac. Residential 27% impervious	100
Greenville	New graded	100

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Determine the weighted average runoff curve number for the watershed described below. Refer to Appendix A of your Study Guide for applicable charts and tables.

Soil Name	Cover Description	Acres	% Area	Hydrologic Soils Group	CN	Product
Dover	Row Crops-SR & CR in good condition	300		B		
New Castle	Meadow-in good condition	200		B		
Crofton	1 ac Residential	200		B		
Odessa	Industrial	100		D		
Dover	1/2 ac. Residential 27% impervious (0.27) (98) + (1-0.27) (61)	100		B		
Greenville	New graded	100		B		
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		1000	1.00			

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Activity 1 - Solution

From the sample soils map and legend sheet on the following pages, determine the percentage of the indicated watershed in each hydrologic soil group. Refer to Appendix A of your Study Guide for applicable chart and tables. For this activity, do not assume the hydrologic soil group has changed because of the urban land complex.

Map Symbol	Soil Name	Hydrologic Soil Group	Acres/ Intersections	%
1	Aledo gr. clay loam, 1 - 8% slopes	C		
2	Aledo-Bolar complex, 5 - 20% slopes	C		
3	Aledo-Bolar-Urban land complex,3 - 20% slopes	C		
4	Aledo-Urban land complex,1 - 8% slopes	C	1006 ac	55%
14	Bolar clay loam, 1 - 3% slopes	C		
15	Bolar clay loam, 3 - 5% slopes	C		
16	Bolar-Urban land complex,1 - 5% slopes	C		
17	Bracket clay loam, 3 - 8% slopes	C		
61	Purves clay, 0 - 3% slopes	D		
62	Purves-Urban land complex,0 - 3% slopes	D		
65	Sanger clay, 1 - 3% slopes		808 ac	45%
66	Sanger clay, 3 - 5% slopes	D		
67	Sanger-Urban land complex,1 - 5% slopes	D		
74	Slidell clay, 1 - 3% slopes	D	1814ac	100%

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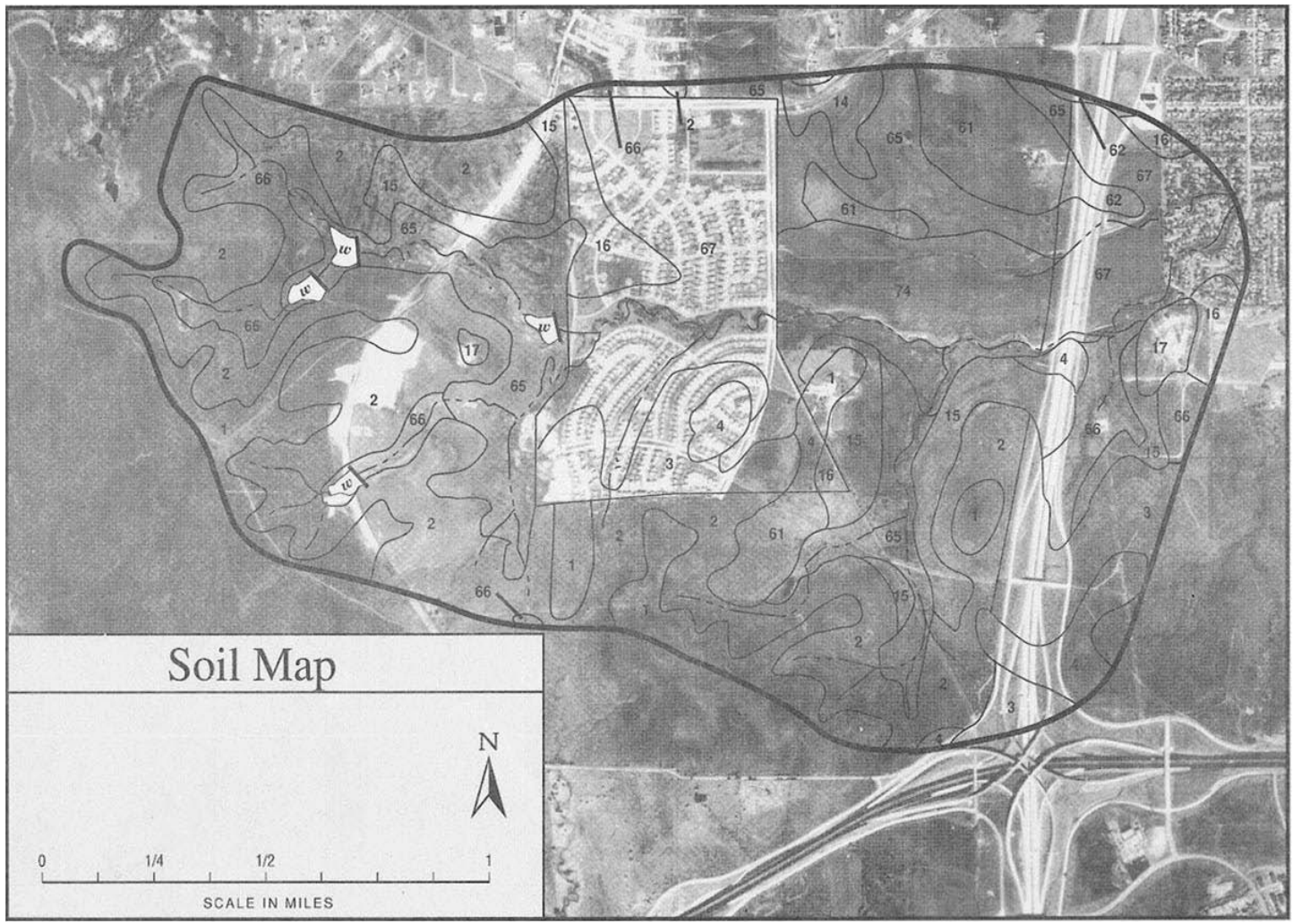
Soil Map
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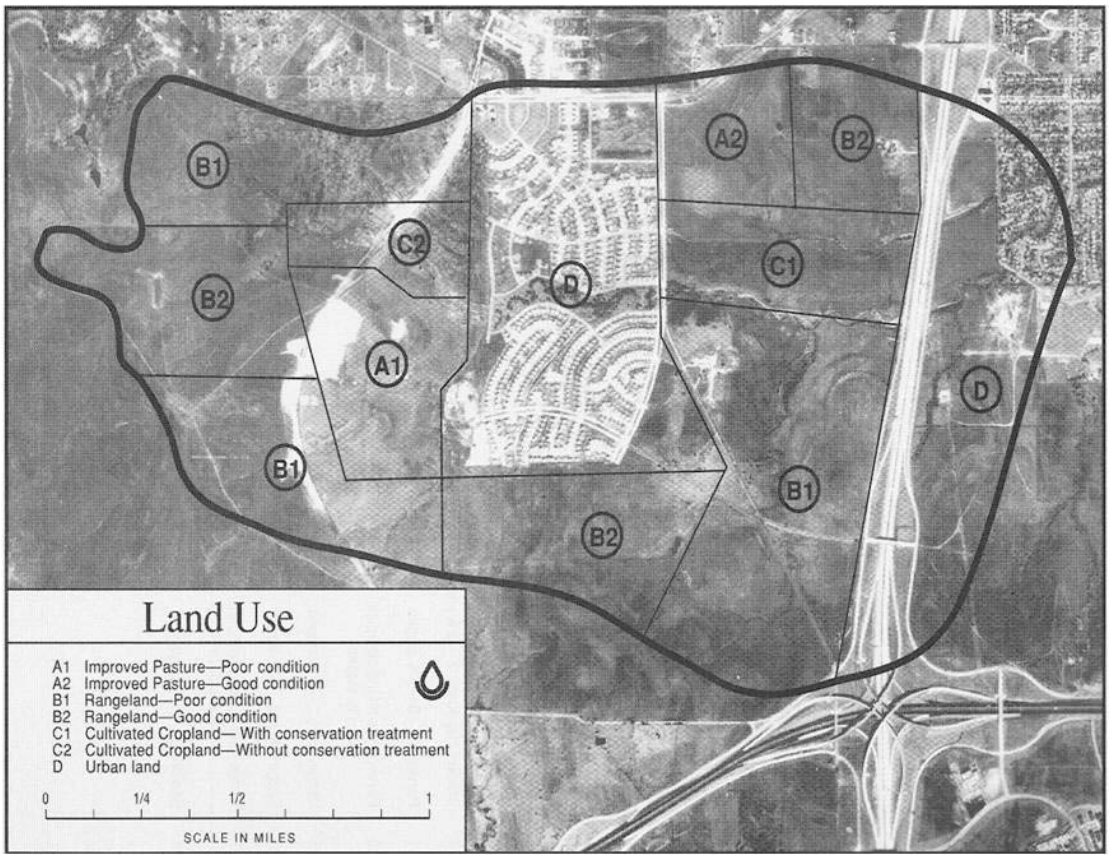
SCALE IN MILES



Activity 2 - Solution

From the sample aerial photograph on the preceding page, determine the percentage of the indicated watershed in each cover description. Refer to Appendix A of your Study Guide for applicable charts and tables.

Land Use	Acres	%
Improved Pasture - poor condition	112	6.2
Improved Pasture - good condition	73	4.0
Rangeland - poor condition	541	29.8
Rangeland - good condition	334	18.4
Cultivated cropland - with cons. treatment.	96	5.3
Cultivated cropland - *wlo* cons.treatment	53	2.6
Urban land	605	33.4
	=1,814	=100.0%

Activity 3 - Solution

Determine the runoff curve numbers for the hydrologic soil cover complexes listed below. Refer to Appendix A (2-2b) of your Study Guide for applicable charts and tables.

HydrologicSoil Group	Cover Description	CN
B	Row crops - straight row & crop residue, in good condition	75
B	Small grain - contoured, in poor condition	74
B	Meadow - in good condition	58
C	Woods - in fair condition	73

Activity 4 — Solution

Determine the runoff curve number for the hydrologic soil cover complexes listed below. Refer to Appendix A (2-2a) in your Study Guide for applicable charts and tables.

HydrologicSoil Group	Cover Description	CN
A	Residential - 1 ac	51
B	Commercial	92
C	New graded area	91
B	Residential-1ac. 18% impervious	(O.18) (98) + (1- 0.18) (61) =67.7 =68

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Activity 5 - Alternate Solution 1

Determine the weighted average runoff curve number for the watershed described below. Refer to Appendix A of your Study Guide for applicable charts and tables.

Soil Name	Cover Description	Acres	Hydrologic Soils Group	CN	Product
Dover	Row Crops-SR & CR in good condition	500	B	75	37,500
Crofton	Small grain-contoured, in poor condition	300	B	74	22,200
Greenville	Meadow-in good condition	150	B	58	8,700
Odessa	Woodsn fair condition	50	D	79	3,950
		=====			=====
		1,000			72,350

Weighted CN= $\frac{72.350}{1000}$ =72.3 use 72

Activity 5 - Alternate Solution 2

Determine the weighted average runoff curve number for the watershed described below. Refer to Appendix A of your Study Guide for applicable charts and tables.

Soil Name	Cover Description	Acres	% Area	Hydrologic Soils Group	CN	Product
Dover	Row Crops-SR & CR in good condition	500	0.50	B	75	37.5
Crofton	Small grain-contoured, in poor condition	300	0.30	B	74	22.2
Greenville	Meadow-in good condition	150	0.15	B	58	8.7
Odessa	Woods-in fair condition	50	0.05	D	79	3.9
		=====	=====			====
		1,000	1.00			72.3
						Use 72

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Activity 6 - Alternate Solution 1

Determine the weighted average runoff curve number for the watershed described below. Refer to Appendix A of your Study Guide for applicable charts and tables.

Soil Name	Cover Description	Acres	Hydrologic Soils Group	CN	Product
Dover	Row Crops-straight row and crop residue, in good condition	300	B	75	22,500
Newberg	Meadow-in good condition	200	B	58	11,600
Crofton	1 ac Residential	200	B	68	13,600
Odessa	Industrial	100	D	93	9,300
Dover	1/2 ac. Residential 27% impervious (0.27)(98)+(1 -0.27)(61)	100	B	71	7,100
Greenville	New graded	100	B	86	8.600
		1,000			72,700

weighted CN = $\frac{72.700}{1,000}$ = 72.7 use 73

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Activity 6 - Alternate Solution 2

Determine the weighted average runoff curve number for the watershed described below. Refer to Appendix A of your Study Guide for applicable charts and tables.

Soil Name	Cover Description	Acres	% Area	Hydrologic Soils Group	CN	Product
Dover	Row Crops-SR & CR in good condition	300	0.30	B	75	22.5
New Castle	Meadow-in good condition	200	0.20	B	58	11.6
Crofton	1 ac Residential	200	0.20	B	68	13.6
Odessa	Industrial	100	0.10	D	93	9.3
Dover	1/2 ac. Residential 27% impervious (0.27) (98) + (1-0.27) (61)	100	0.10	B	71	7.1
Greenville	New graded	100	0.10	B	86	8.6
		=====	====			===
		1000	1.00			72.7

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